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LOCAL GLACIATION IN THE CATSKILL MOUNTAINS

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The Catskills, next to the Adirondacks, are the highest mountains in New York state. Several peaks rise well above 4,000 feet, while the great majority of the mountains in the central part of the area have an elevation exceeding 3,000 feet. Such an elevation naturally produces greater precipitation and a climate considerably colder than that of the surrounding country, as the following extracts from the report of the New York Weather Bureau plainly show. Five stations have been selected for comparison: Griffin's Corners, in the heart of the Catskills; Oneonta, in the foothills to the north; Albany, Binghamton, and Ithaca. Mean temperature for the years 1901–4: Griffin's Corners, 42.8°; Oneonta, 45.6°; Albany, 47.5°; Binghamton, 45.9°; Ithaca, 46.0°. Normal annual precipitation: Catskills, 40″–50″; Binghamton, 35″–40″; Albany, 35″–40″; Ithaca, 30″–35″. Winter conditions prevail there two or three weeks earlier, and persist two or three weeks longer, than in the lower parts of the state. This comparatively cool climate is an important factor, which must be taken into account in a study of the former glaciation of the region.

Comparatively little detailed work has been done on the glacial geology of the Catskills. Studies of a reconnaissance nature have, however, disclosed evidences that, in the higher mountains local glaciers persisted after the withdrawal of the continental ice-sheet. Such a condition is known to have prevailed to a greater or less extent in the Adirondacks, the White and Green Mountains, and the Katadn region of Maine. In New England, especially during the earlier study of glacial geology, considerable attention was given to the question of local mountain glaciation. A brief outline of the results of this work is given in the following section.

PREVIOUS ANNOUNCEMENT OF VALLEY GLACIERS

As early as 1856 Edward Hitchcock[1] described striæ and moraines showing a movement of ice down valleys in a direction different from that of the principal ice-movement. Later C. H. Hitchcock,[1] Packard,[2] and Vose[3] brought forward further evidence of the same nature. Dana,[4] in view of the results of his study in the Connecticut valley, attributes most of these so-called evidences of local glaciation to the work of valley tongues from the margin of a waning ice-sheet. In a later paper[5] he suggests the probability of local glaciers having remained in the White Mountains after the ice-sheet had withdrawn. Agassiz,[6] having found a terminal moraine containing bowlders transported *northward* from their parent ledges on Mount Washington, was the first to show definitely that glaciers had moved out from the White Mountains in a direction opposite to that of the general ice-movement. C. H. Hitchcock[7] has repeatedly called attention to evidences of valley glaciation among the mountains of New England, and in his later papers[8] suggests that ice from the higher mountains, in the form of a local ice-cap, pushed outward in every direction, reaching as far north as Canada. Tarr[9] has shown that local valley glaciers existed on Mount Katadn, Maine, and suggests that further study of that region is likely to show that valley glaciers descended from several of the mountains in the vicinity. Upham[10] believes that "at the close of the glacial period, the Adirondacks, the Green and White Mountains, with probably the greater part of Maine, continued ice-covered after the glacial blockade was melted through along the Hudson, Champlain, and St.

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[1] *Smithsonian Contributions*, Vol. IX (1856), Art. III, pp. 135–44.

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[1] *Proceedings of the American Association for the Advancement of Science*, Vol. XIII (1859), pp. 329–35.

[2] *American Journal of Science*, Vol. XLIII (1867), p. 42; *American Naturalist*, Vol. I (1868), pp. 260–69.

[3] *American Naturalist*, Vol. II (1868), pp. 281–91.

[4] *American Journal of Science*, Series 3, Vol. II (1871), pp. 233–43.

[5] *Ibid.*, Vol. V (1874), pp. 198–211.

[6] *Proceedings of the American Association for the Advancement of Science*, Vol. X (1870), pp. 161–69.

[7] *Geology of New Hampshire*, Vol. I (1874), pp. 539–44; *ibid.*, Vol. III (1878), pp. 181–340; *Proceedings of the American Association for the Advancement of Science*, Vol. XXIV, Part II (1875), pp. 92–96; *Report of the Vermont State Geologist*, 1903–4, pp. 67–85.

[8] *Journal of Geology*, Vol. IV (1896), p. 60; *Bulletin of the Geological Society of America*, Vol. VII (1896), pp. 3, 4.

[9] *Bulletin of the Geological Society of America*, Vol. XI (1900), pp. 433–48.

[10] *American Geologist*, Vol. XXI (1898), pp. 169, 170, 380; *American Journal of Science*, Series 3, Vol. XLIX (1895), pp. 1–18; *Twenty-third Annual Report of the Geological Survey of Minnesota*, 1894.

Lawrence valleys." He has shown[1] that the moraine described by Agassiz, to which reference has already been made, is a part of a morainic belt encircling the White Mountains, and was formed at the margin of the local ice-cap which once covered them. At a later stage small local glaciers persisted in the mountain valleys.

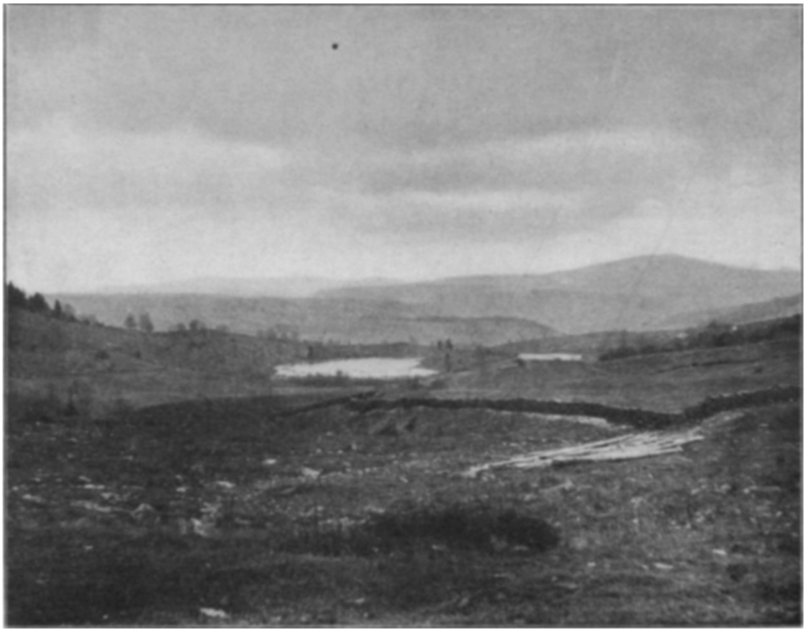

FIG. 1.—View of a lake and its inclosing moraine built by a local glacier which descended from one of the higher ranges of the Catskills. This photograph was taken from the steep mountain valley down which the ice moved. In the foreground is a hummocky deposit representing later stands of the ice.

In the Adirondacks, Cushing[2] mentions evidence of the existence of valley glaciers either during or shortly after the retreat of the ice. Tarr, to whom I am indebted for references and helpful suggestions in the preparation of this paper, informs me that the Ausable lakes show evidences of having been formed by deposits from valley glaciers.

[1] *American Geologist*, Vol. XXXIII (1904), pp. 7–14.

[2] *Sixteenth Annual Report of the State Geologist*, New York (1896), p. 8; *New York State Museum Bulletin*, 95, 1905, p. 437.

Chamberlin[1] suggests that, in the Catskills, some of the minor moraines scattered through the mountain valleys may be due to independent local glaciers. Of this region Smock[2] writes:

> The valleys are essentially of erosive origin, obscured, however, now by glacial débris in many places. In some of them, as that of the Batavia Kill at Windham, the Stony Clove, and Woodland valley, there are very plainly marked moraines indicating the existence and retreat of local glaciers. The larger valleys of the Schoharie Kill, the East branch of the Delaware, and the Esopus Creek, also have their moraines, though not so well defined. Subsequent to the retreat of the great mass of the continental glacier these valleys were no doubt occupied by detached glaciers.

The above summary shows that the former existence of local glaciers in the mountains of New England and New York has been recognized, in some places as certain, in others as very probable. It is the purpose of this paper to describe a definite instance of local glaciation in the Catskills.

Location and topography.—The region covered by this paper lies in the northern part of the Catskills, roughly speaking at the junction of Schoharie, Greene, and Delaware Counties, and includes a part of each.[3] The Schoharie Creek, flowing northward, is the principal stream. It occupies a rather narrow, deep valley whose floor at Gilboa has an elevation of 1,000 feet, and at Prattsville, four miles south, 1,100 feet. South of Prattsville the mountains rise directly up from the valley to elevations varying from 3,000 to 4,000 feet, while north of that village is a dissected plateau with a general elevation of about 2,000 feet. All the mountains south of Prattsville, and the higher portions of the plateau to the north, are made up of Oneonta-Catskill red and gray sandstones and red shales, which give to the soil a very characteristic red color, easily distinguished from the bluish or yellow color of the northern drift.

About three miles west of Prattsville, at the head of Fly Brook, a tributary to the Schoharie is a large U-shaped amphitheater in the mountains, with the open side toward the northeast, and with a breadth of about two miles from crest to crest of its inclosing rim. On the south and southwest portions of the rim are the two highest peaks—Roundtop Mountain, 3,448 feet, and Bloomberg Mountain, 3,360 feet. Three spurs from the mountain divide the amphitheater into four minor basins. It is within this amphitheater that the evidence of valley glaciers may be seen.

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[1] *U. S. Geological Survey, Third Annual Report*, p. 373.

[2] *American Journal of Science*, Series 3, Vol. XXV (1883), pp. 346–50.

[3] Gilboa sheet, U. S. Geological Survey.

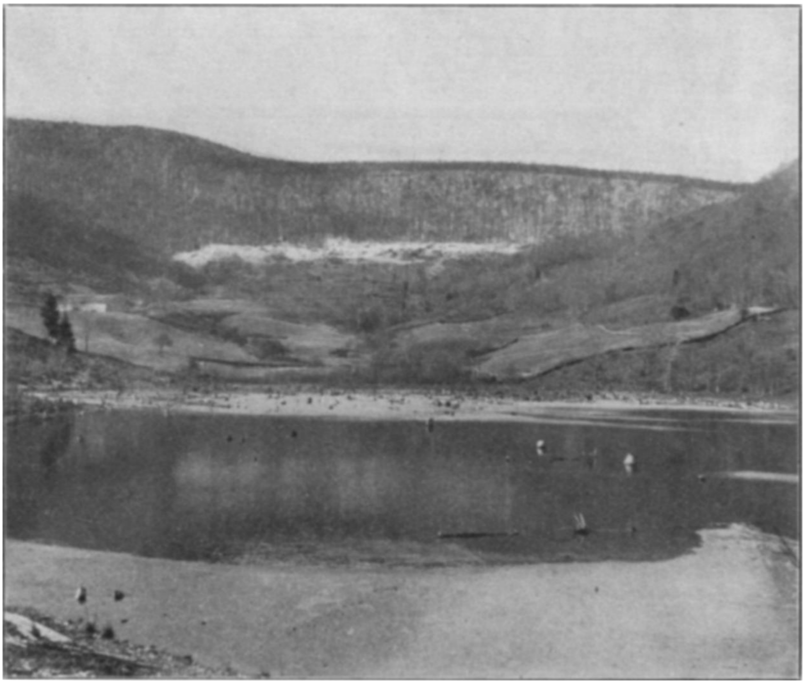

FIG. 2.—Looking up the valley from the terminal moraine. In the center is the hummocky moraine formed by the retreating glacier. One distinct loop may be seen in the middle of the valley. On the extreme right the lateral continuation of the terminal loop is shown running diagonally up the hillside.

VALLEY GLACIERS

In the central and largest of the four basins there lies a small lake[1] held up by a morainic loop which swings in a crescent across the valley, then diagonally up the hill slope on either side. (Fig. 1), taken from the mountain a little below the snow, shown in Fig. 2, shows the lake and moraine as they appear from the mountain side down which the ice moved. It also clearly shows the hummocky surface in the foreground, and on the left the moraine loop curving diagonally up the hillside.

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[1] The lake has been enlarged by a dam across its narrow outlet.

The moraine, which forms an irregular ridge at least 60 feet high in places, has a rather abrupt slope on the down-stream side, and from its terminus a somewhat gravelly deposit, evidently of outwash origin, stretches away down-stream. Above the lake, for a distance of half a mile, is a thick, hummocky morainic deposit showing one or two fairly distinct ice-stands. This feature is shown in Fig. 2, taken from the terminal loop looking up the valley down which the ice came. On the extreme right of this picture the lateral continuation of the loop is shown running diagonally up the hillside (see also Fig. 1). Figs. 3 and 4 are nearer views of the lake and moraine seen from opposite sides of the lake.

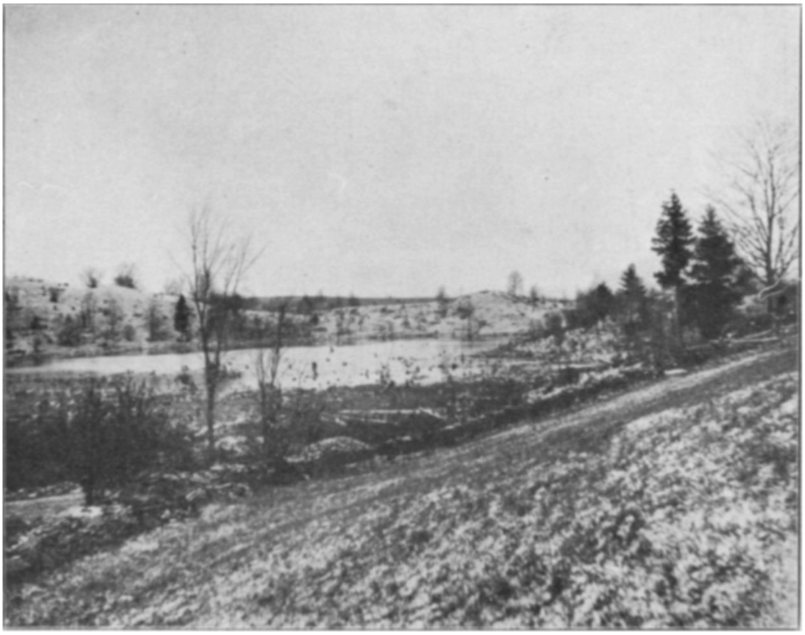

FIG. 3.—A nearer view of the terminal loop. Its semicircular form is well shown.

The evidences of extinct valley glaciers in this amphitheater are not confined to the one basin just described. East of it are two basins each of which had its glaciers. The first of these has a morainic loop just as perfect, though not so large, as the one which holds the lake. It shows even better the lateral moraines on each side running diagonally down the hill and joining in the terminal loop. Within this moraine, and concentric with it is another smaller, though very distinct, loop. Between these moraines and the mountain, the bottom of the basin is moraine-filled like that of the larger valley already described.

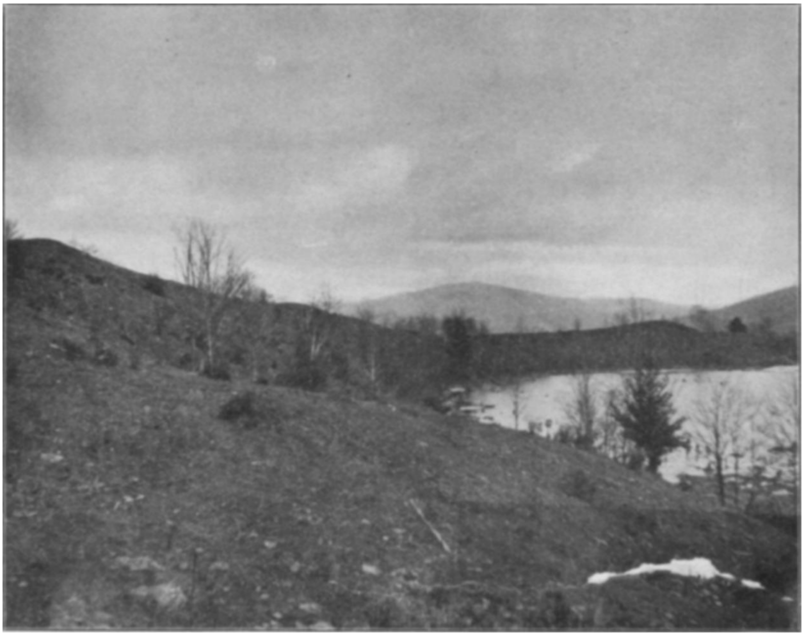

FIG. 4.—A view along the moraine front from the point where the loop joins the hillside. Above this point the lateral moraine continues for nearly half a mile up the hillside. Below, it swings in a beautiful crescent across the valley.

The second basin is less pronounced than the first, and contains, consequently, a less conspicuous, though perfectly distinct, moraine.

Between the terminal moraine and the mountain is a hummocky topography resembling that in the other basins.

The remaining basin, lying west of the lake, I did not examine closely. It is thickly wooded, and may or may not contain local moraines.

These morainic accumulations are composed almost exclusively of local material. In the course of a half-day spent in tramping over them, during all of which time a constant lookout for foreign rock fragments was maintained, I found only one stone, a small piece of gneiss, of other than local origin. This strictly local nature of the morainic débris, taken in connection with the fact that all the terminal loops are convex down-stream and all have distinct lateral moraines leading down to them from the hillsides, shows conclusively that for an explanation we must look to local valley glaciers, and not to the continental ice-sheet, or tongues from it, pushing up toward the mountain from the north.

The valley of Fly Brook, all the way from the lake to its junction, with the Schoharie Creek, a distance of three miles, suggests strongly the idea that it was once occupied for its entire length by a valley glacier. One and one-half miles below the lake, and about 20 rods below the schoolhouse, are exposures of rock by the roadside showing striæ running in a northeast and southwest direction parallel with the axis of the valley. Patches of moraine along the valley sides, the U-shape of the valley bottom, and a peculiar morainic deposit where Fly Brook joins the Schoharie, all suggest a valley glacier.

PROBABLE EXTENDED LOCAL GLACIATION

There is some evidence that south of Gilboa the Schoharie valley and its tributaries were for a long time occupied by ice moving northward and outward from the higher Catskills. The reconnaissance nature of my visit to this region did not permit me to gather evidence enough to fully substantiate this hypothesis, but there are many facts which strongly suggest it. The following show the nature of the evidence: (1) The local nature and red color of the moraines are very conspicuous. At Gilboa, in the Schoharie valley, is a deep morainic accumulation of distinctly northern drift, containing numerous pebbles and bowlders of limestone and crystallines, and having a decided yellowish color entirely characteristic of the northern drift, and very different from the red of the local rocks. Overlying this is a thick deposit of lake clay of the same yellowish color. At Devasego Falls, three miles farther south in the same valley, is a moraine of an entirely different character. It is convex down-stream; it consists largely of local, red débris, and is overlain by several feet of *red* lake clay. South of Devasego Falls, in the Schoharie and its tributaries, the moraines are composed very largely of this local red material. (2) Moraines across the Schoharie valley and its tributaries are, apparently in every case, convex down-stream. This is especially well shown at Devasego Falls, along the Manor Kill west of Conesville, and along the Batavia Kill between Prattsville and Ashland. (3) There are lateral moraines leading into these loops in a direction indicating ice-movement, out from the mountains.

SUMMARY

The elevation and consequent low temperature of the Catskills would enable them to support glaciers while the surrounding lower lands were entirely deserted by the ice. In one valley at least, local glaciers *did* exist for a period of time long enough for the building of a morainic loop 60 feet high in places. Evidences in the Schoharie valley point toward quite an extensive movement outward and northward from the mountains.